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Intra- and inter-observer agreement on diagnosis and measurements of Dupuytren disease severity

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ABSTRACT

INTRODUCTION: Dupuytren disease (DD) is a fibrosing disease affecting the palmar aponeurosis, and is mostly treated by surgery based on measurement of severity of the disease. Literature concerning the measurement reliability is scarce. This study aimed to determine the intra- and inter-observer agreement of four variables for diagnosing DD and its severity. One of them is a new measurement on the area of nodules and cords for measuring the severity in early stage of the disease.

METHODS: An agreement study (n = 54) was performed by two trained investigators. Agreement was calculated based on an intraclass correlation coefficient (ICC) using a latent variable model on subjects for diagnosis and Tubiana stage. For total passive extension deficit (TPED) and the area of nodules and cords agreement was calculated with an ICC using a one-way random effects model with subject as random effect. Agreement for each variable was determined per finger.

RESULTS: Inter-observer agreement was very good for diagnosing DD (ICC: 95.5 – 99.9) and good to very good for classifying Tubiana stage (ICC: 73.5 – 94.9). Agreements for area and TPED were moderate (middle finger) to very good (ICC: 48.4 – 98.6 and 45.0 – 99.5, respectively). Intra-observer agreement was slightly higher on average than inter-observer agreement.

CONCLUSION: Overall, the intra- and inter-observer agreement in diagnosing DD and determining its severity is high. Also, the newly introduced variable area of nodules and cords has high intra- and inter-observer agreement, indicating that it is suitable to measure disease severity.

INTRODUCTION

Dupuytren disease (DD) is a fibrosing disease affecting the palmar aponeurosis of the hand. This proliferation of fibrous tissue can lead to the formation of nodules and cords in the palm and fingers. These cords may contract, causing permanent flexion contractures of the fingers. Consequently, this often results in physical complaints.

The prevalence of DD ranges between 0.6 and 31.6% in the general population (Lanting et al., 2014). Despite conflicting results about the role of risk factors (Bergenudd et al., 1993; Godtfredsen et al., 2004; Zerajic and Finsen, 2004; Lucas et al., 2008), older age and male sex are clearly associated with a higher prevalence (Gudmundsson et al., 2000; Lanting et al., 2013). In combination with the fact that the population is ageing and the life expectancy increases in western countries (World Health Organization, 2011; van Duin and Stoeldraijer, 2012), it can be expected that the number of patients suffering from DD will increase.

Until now, DD cannot be cured; treatment is aimed at reducing the flexion contractures of the fingers. These can be corrected using different treatment options (van Rijssen and Werker, 2009), but most patients are treated surgically. Unfortunately, long-term recurrence rates are varying between 21% - 85% (van Rijssen et al., 2012; Peimer et al., 2013), depending on the type of treatment (van Rijssen et al., 2012). Because of these high recurrence rates, clinicians are often reluctant to perform surgery.

The decision to surgically intervene is usually based on the extension deficit (i.e. the severity of contracture) measured with a goniometer, and on the anamnestic

progressiveness of this extension deficit in one or multiple fingers (Au-Yong et al., 2005). However, it is unclear how reliable these goniometry measurements are. Despite numerous reports concerning the reliability of goniometry in the upper extremity (van de Pol et al., 2010), there are only a few studies that have investigated the reliability of these measurements in finger joints (Ellis et al., 1997; Lewis et al., 2010; Macionis, 2013). In addition, these studies were performed in healthy subjects without hand disorders. Recently, one study was performed to determine the reliability of goniometry of the finger joints in DD patients (Engstrand et al., 2012). However, only the active range of motion was determined in that study, instead of the passive extension deficit, which is often a decisive factor in the choice of treatment (Hurst, 2011).

The severity of DD is mainly determined using goniometry, and classified by the classification of Tubiana (Tubiana et al., 1967). However, the majority of DD patients in the general population have mild disease without contractures (Gudmundsson et al., 2000; Degreef and De Smet, 2010; Lanting et al., 2013). Hence, it is not possible to measure disease progression in this patient group using goniometry. In two previous studies an alternative measurement method is reported, where the nodules and cords are encircled and registered using a photocopy of the hands (Herbst and Regler, 1986; Seegenschmiedt et al., 2001). However, it is unclear how the disease severity was quantified in these studies. To our knowledge, there is no alternative measurement to determine progression of disease in patients with mild disease. Therefore, we introduce the use of a tumorimeter to determine the size of nodules and cords. If this new measurement will be reliable, it can be used for example to study short term progression of disease, or to study occurrence and progression of recurrent disease.

The aim of this study is to determine the intra- and inter-observer agreement of four different measurement variables for diagnosing DD and its severity, namely: 1) the diagnosis itself, 2) Tubiana stage, 3) total passive extension deficit measured with a goniometer, and 4) the area of nodules and cords.

METHODS

Participants

Adults with primary DD were asked to participate in this study. A sample size of 41-77 participants was needed to retrieve with 90% assurance an intra-class correlation (ICC) of 0.80 with a maximum confidence interval (CI) width of 0.3 (Zou, 2012).

Therefore, taking non-response into account, 77 patients were asked to participate. Participants were included if they had primary DD in at least one hand, and were excluded if they were incapacitated. All participants gave written informed consent. The medical ethics committee of the University Medical Center Groningen approved this study.

Observers

The measurements were performed by two observers. The first is a medical doctor (RL) with extensive experience in diagnosing different stadia of DD. The second observer (DB) is a human movement scientist, and was trained in diagnosing DD prior to this study. During this training, she physically examined both hands of 50 DD patients with unilateral or bilateral disease and various disease stadia, without prior knowledge about the location of the nodules and cords. Thereafter, her findings were evaluated by the first

observer, and both observers examined the hands together. Inconsistencies were then discussed to learn the second observer how to judge in these cases of doubt.

Outcome variables

Below, the different outcome variables are enumerated, whereby DD in the palm of the hand was registered as DD in the finger of the corresponding ray. For example, a palmar nodule in line with the ring finger was registered as DD in the ring finger. Nodules and cords of the first web space, for example originating from the distal and proximal commissural ligaments, were recorded as an affected thumb.

1. Diagnosis of DD:

   This was determined by physical examination of the hands. The diagnosis of DD was registered binary (yes/no) for each finger separately.

2. Tubiana stage:

   The Tubiana stage was determined by transferring the TPED of each ray into this classification system (Tubiana, 1986). To avoid ambiguity, the range of TPED of the original classification was adapted (Table 1).

3. Total passive extension deficit (TPED):

   This was measured in degrees using a Rolyan flexion-hyperextension finger goniometer (Smith&Nephew, Hull, UK, photo 1). To determine the passive extension deficit (PED), the participants placed their elbow on the table, and were asked to relax their hand and fingers. Then, the fingers were passively extended by the observer, until resistance was felt. At this point, the PED was measured of each joint separately. The joints were measured from proximal to distal, where the proximal joints were held in extension during the measurement

of the distal joint. For the measurements at the fourth and fifth fingers, the observer blocked the carpometacarpal (CMC) joint in extension, to prevent measurement errors that can occur when the CMC joint is not blocked (Eaton, 2012). If applicable, hyperextension was also measured. The PED of the metacarpophalangeal (MCP) joint, proximal interphalangeal (PIP) joint, and distal interphalangeal (DIP) joint were summed to acquire the TPED of each finger separately. The TPED was not measured in the thumb. TPED that was measured in a finger without DD (so due to other conditions), was not registered.

4. Area of the nodules and cords:

   For round-shaped nodules, a plastic tumorimeter (Pfizer Oncology, PharmaDesign Inc.,China, photo 2) was used to determine the area in square centimeters. To determine the area of other shaped nodules or cords, the length and width (at three locations) was measured using the caliper on the tumorimeter. Afterwards, the area was calculated.

Table 1. Original and adapted version of the Tubiana classification system.

Stage	Original classification	Our classification
0	No Dupuytren disease	No Dupuytren disease
N	Lesion without contracture	Lesion without contracture
1	0 to 45º	0 to 45º
2	45 to 90º	46 to 90º
3	90 to 135º	91 to 135º
4	> 135º	> 135º

Procedure

A schematic representation of the study procedure is given in Figure 1. The measurements took place at the outpatient clinic of the department of Plastic Surgery of the University Medical Center in Groningen, The Netherlands. First, the hands of the participants were examined only by the first observer. The nodules and cords were encircled using an erasable skin pencil. Then, the area of the nodules and cords was measured, followed by the PED of the affected fingers (when indicated).

To determine the intra-observer agreement, the participants returned 2-4 weeks later for the second measurements. This term was chosen in order to limit the possibility of disease progression, but to ensure that the observer was not able to remember the first measurements. The nodules and cords were encircled again, and the area and PED were measured by the first observer. In addition, a picture was made of both hands with the pencil lines. Thereafter, participants washed their hands thoroughly, to erase the pencil lines.

To determine the inter-observer agreement, the participants were examined by the second observer immediately after the second measurement of the first observer, following the same procedure and using the same instruments. After performing all measurements, the findings of the two observers were compared to detect data entry errors. The pictures of the hands taken by the two observers were used to determine whether there was a data entry error or not.

Statistical analyses

Only measurements of primary affected hands were analyzed, and all analyses were performed for each ray separately. Descriptive statistics are presented by means with range for continuous data. Frequencies with percentages are given for nominal variables. Non-normal data (area of nodules and cords) were transformed with square root to achieve normality.

Agreement on DD and Tubiana was calculated with an intraclass correlation coefficient (ICC) using a latent variable for subjects underneath the binary or ordinal outcome. The continuous outcomes were analyzed with a one-way random effects model where subjects were considered the random effects on fingers with agreed positive diagnosis. Agreement was measured with and ICC and 95% confidence intervals were calculated with the Beta approximation (Demetrashvili et al., 2014). Criteria for evaluation of ICC are shown in Table 2 (Altman, 1991).

Table 2. Criteria for evaluation of ICC(Altman, 1991)

Value ICC	Strength of agreement
<20%	Poor
21-40%	Fair
41-60%	Moderate
61-80%	Good
81-100%	Very good

RESULTS

In total, 54 participants (33 males and 21 females) with 78 primary affected hands were included in this study. Mean age of participants was 65.8 years (SD 9.2). DD was

diagnosed by both observers in 194 fingers (Figure 2). In 8 fingers there was no consensus between the two observers about the presence of DD.

In Table 3, the differences in the area of nodules and cords, and the TPED between the first and the second measurement of observer 1 are presented. Also, the differences between the measurements of observer 1 and observer 2 are presented. For the intra-observer agreement, the positive mean differences indicate that the first measurement was larger than the second measurement, and vice versa. For the inter-observer agreement, the positive and negative mean differences indicate that the observers measured both larger as well as smaller values, compared to other observer. Regarding the measurements of the area and TPED, there were only small differences within the observer as well as between the observers. However, the dispersion is larger in the measurements of TPED compared to the area, especially with respect to the inter-observer comparison.

Table 3. Mean differences in total passive extension deficit and in area of nodules and cords, between observations.

Intra-observer comparison	*Left*		*Right*	
Δ Area	cm^2 ± SD	Range	cm^2 ± SD	Range
Thumb	0.00 ± 0.43	-0.48 – 1.15	-0.03 ± 0.35	-0.61 – 0.75
Index finger	-0.23 ± 0.30	-0.50 – 0.16	0.10 ± 0.32	-0.05 – 0.67
Middle finger	0.01 ± 0.30	-0.80 – 0.55	0.12 ± 0.54	-0.50 – 2.10
Ring finger	-0.07 ± 0.62	-1.94 – 1.46	-0.07 ± 0.52	-1.68 –1.42
Little finger	-0.10 ± 0.41	-1.41 – 0.57	0.00 ± 0.67	-2.45 – 1.53
Δ TPED	^{0} ± SD	Range	^{0} ± SD	Range
Index finger	2.0 ± 1.0	0 – 4	0.4 ± 0.9	0 – 2
Middle finger	-0.1 ± 3.2	-8 – 9	0.5 ± 2.3	-4 – 8
Ring finger	0.9 ± 3.4	0 – 16	1.4 ± 4.6	-2 – 24
Little finger	-1.2 ± 3.9	-16 – 0	1.2 ± 5.4	-10 – 21
Inter-observer comparison	*Left*		*Right*	
Δ Area	cm^2 ± SD	Range	cm^2 ± SD	Range
Thumb	0.02 ± 0.46	-0.94 – 0.90	-0.27 ± 0.38	-0.82 – 0.40
Index finger	0.25 ± 0.44	-0.35 – 0.67	0.03 ± 0.17	-0.15 – 0.28
Middle finger	0.18 ± 0.47	-0.93 – 0.95	0.04 ± 0.59	-1.52 – 0.84
Ring finger	0.46 ± 0.91	-0.76 – 3.55	0.28 ± 0.46	-0.55 – 1.45
Little finger	0.22 ± 0.53	-0.50 – 2.01	0.45 ± 0.86	-1.15 – 3.22
Δ TPED	^{0} ± SD	Range	^{0} ± SD	Range
Index finger	1.0 ± 2.0	0 – 4	-2.0 ± 4.5	-10 – 0
Middle finger	1.8 ± 5.0	0 – 16	-0.6 ± 2.0	-8 – 2
Ring finger	-2.1 ± 10.3	-55 – 8	-2.3 ± 7.8	-36 – 0
Little finger	-0.4 ± 3.6	-10 – 10	-0.7 ± 4.7	-15 – 10

Agreement on DD and measurements

The agreement for diagnosing DD was very good. The smallest ICC for inter-observer agreement was observed for the little finger in the left hand: ICC [95%CI] = 95.5% [94.5% ; 96.4%]. All other fingers scored an ICC higher than 99.0%. The intra-observer

agreement was only worse than the inter-observer agreement in the right ring finger (99.5% versus 99.9% respectively).

The ICCs for the other outcome measurements are reported in Tables 4a, b, and c. These Tables show that on average the intra-observer agreement is higher than the inter-observer agreement. The range in agreement is smallest for Tubiana stage (ICC 73.5 – 98.9), which is emphasized by the contingency table on Tubiana stage (Table 5). The range in agreement is largest for TPED (ICC 45.0 – 99.8). With respect to TPED, the agreements in the left middle finger are moderate. Regarding surface area, the agreement was very good in the majority of the fingers, however, agreement in the thumb and middle finger was considerably lower than in the other fingers. The measurement error of TPED ranges between 2.5º (right index finger) and 13.8º (left little finger) for the intra-observer agreement, and between 5.6º (left index finger) and 15.2º (left ring finger) for the inter-observer agreement.

Table 4a. Intraclass correlation coefficients for agreement in Tubiana stage with 95% confidence intervals

	Intra-observer agreement		Inter-observer agreement	
	Left	Right	Left	Right
Thumb	98.9 [98.9 ; 99.0]	98.3 [98.2 ; 98.5]	94.9 [93.8 ; 95.8]	93.9 [92.4 ; 95.3]
Index finger	93.9 [92.7 ; 94.9]	94.2 [93.2 ; 95.2]	86.7 [82.6 ; 90.2]	86.6 [82.3 ; 90.4]
Middle finger	85.9 [81.6 ; 89.8]	83.4 [78.4 ; 87.9]	91.8 [90.1 ; 93.3]	88.9 [86.2 ; 91.3]
Ring finger	93.1 [91.9 ; 94.3]	98.2 [98.0 ; 98.4]	73.5 [64.6 ; 81.5]	88.4 [85.8 ; 90.9]
Little finger	93.5 [92.0 ; 94.9]	86.9 [83.1 ; 90.4]	86.1 [82.8 ; 89.0]	82.8 [77.3 ; 87.6]

Table 4b. Intraclass correlation coefficients for the agreement of TPED measurements with 95% confidence intervals

	Intra-observer agreement		Inter-observer agreement	
	Left	Right	Left	Right
Thumb	NA[a]	NA[a]	NA[a]	NA[a]
Index finger	96.0 [84.6 ; 99.9]	99.5 [98.4 ; 100.0]	92.3 [71.1 ; 99.9]	92.3 [74.3 ; 99.7]
Middle finger	47.9 [15.8 ; 81.1]	92.2 [84.9 ; 97.2]	45.0 [12.9 ; 79.9]	85.2 [72.5 ; 94.5]
Ring finger	99.8 [99.6 ; 99.9]	91.0 [84.6 ; 95.8]	96.1 [92.9 ; 98.3]	92.8 [87.7 ; 96.6]
Little finger	97.4 [94.6 ; 99.2]	94.8 [90.2 ; 98.0]	98.5 [96.8 ; 99.5]	96.8 [93.7 ; 98.9]

a. Not applicable, because TPED was not measured in the thumb.

Table 4c. Intraclass correlation coefficients for the agreement of measurements of area of DD with 95% confidence intervals

	Intra-observer agreement		Inter-observer agreement	
	Left	Right	Left	Right
Thumb	82.2 [65.0 ; 94.4]	50.8 [17.4 ; 83.8]	72.9 [49.4 ; 90.9]	63.3 [32.4 ; 89.0]
Index finger	98.6 [94.5 ; 100.0]	95.2 [83.8 ; 99.8]	96.7 [87.0 ; 100.0]	95.9 [85.8 ; 99.9]
Middle finger	82.9 [65.6 ; 94.9]	88.0 [77.1 ; 95.6]	48.4 [16.3 ; 81.3]	69.3 [47.1 ; 87.5]
Ring finger	97.1 [94.8 ; 98.8]	95.8 [92.7 ; 98.1]	90.6 [83.4 ; 95.9]	93.0 [88.0 ; 96.7]
Little finger	93.8 [87.3 ; 98.0]	91.9 [84.8 ; 96.8]	87.6 [75.7 ; 95.9]	93.6 [87.4 ; 97.8]

Table 5. Contingency table on Tubiana stage. There were no patients with Tubiana >2 in our sample.

		Observer 1			
		0	N	1	2
Observer 2	0	196	4	0	0
	N	2	157	4	0
	1	2	1	19	0
	2	0	0	1	4

DISCUSSION

The aim of this study was to determine the intra- and inter-observer agreement of different variables concerning diagnosis and disease severity in patients with primary DD. Secondly, we introduced a new variable to determine disease severity: area of nodules and cords, measured with a tumorimeter.

Regarding to diagnosis, the intra- and inter-observer agreement was very good in almost all fingers. The agreement was not 100%, which shows that despite the experience of the observer, there are always cases in which there is uncertainty about the presence of DD, for example because of the difficulty in distinguishing DD tissue from normal structures in cases with early DD. The high inter-observer agreement on diagnosis indicates that a relatively inexperienced observer is able to recognize DD after a short training period, even in participants with an early stage of DD without contractures. This is an important finding, since in several studies the results are sometimes questioned if the study was performed by a less experienced investigator (Godtfredsen et al., 2004; Zerajic and Finsen, 2004; Lanting et al., 2013). In addition, the agreement on Tubiana stage was also very good.

One of the aims of this study was to investigate the agreement on measurement of TPED. Since the PED of thumb's MP and IP are very much influenced by the position of the CMC, the thumb was excluded from this study. With respect to TPED in the remaining fingers, the intra- and inter-observer agreement was very good, indicating that reliable values can be obtained when consecutive measurements are performed by the same or another physician in clinical practice. However, both the intra- and inter-observer agreement in the left middle finger were moderate. It could be that TPED is harder to measure on the left hand when the investigator is right handed. Another possibility is that dynamism during the measurements of TPED is responsible for this lack of agreement. Dynamism is the phenomena that the extension deficit of one joint can be influenced by the position of the other joint, especially when a contracture affects both the MCP and PIP joint (Rodrigues et al., 2014). However, if dynamism is responsible for the low agreement, it would be expected that the agreement in some other fingers was low too. Furthermore, since both observers measured participants in the same way, the effect of dynamism on the agreement will be negligible. The low agreement might also be caused by difficulties with the measurements in patients with additional conditions, such as arthritis or knuckle pads. Such conditions often result in thickened PIP or DIP joints, which complicates the measurements, and can lead to an overestimation of the extension deficit.

In the literature, many different methods to measure extension deficit (ED) are reported: active extension loss (Reilly et al., 2005), total ED (Johnston et al., 2008), and total passive ED (van Rijssen and Werker, 2006). In some articles, the used method to measure ED is not reported at all (Citron and Hearnden, 2003; Jurisic et al., 2008; Ullah et al., 2009), while the method is likely to influence the results. These different measurement methods complicate the comparison of different studies. It is favorable to

use one and the same method, and our results show that TPED might be a good choice. However, the large ranges of the TPED in some fingers underline the necessity of taking measurement errors into account, especially in case the TPED is used to decide for a surgical treatment. In the current clinical practice, it is advised to round the range of motion measurements to the nearest ten for each joint (American Medical Association, 2008). This suggests that measurements of TPED can have a dispersion of 15º, because TPED consists of measurements of three joints. Our results show that on average the expected maximum error of unrounded measurements is at most 15º, indicating that it is unnecessary to round TPED measurements. It should be noted that the actual difference between observers in individual patients can be larger.
With this in mind, we recommend that in clinical practice the decision to perform surgery should be not only be based on TPED, but also on change over time in combination with the complaints that the patient report. Future studies should be performed to provide more insight in the reliability of the different methods to measure ED, and to study the natural disease progress.

With respect to the measurements of the area of nodules and cords, the intra- and inter-observer agreement were good to very good in all fingers, except for the left middle finger and the right thumb. The latter might be explained by the fact that the distal and proximal transversal commissural ligaments in the first web space can easily be mistaken for DD cords in participants with thin skin (Tubiana et al., 1982; Rayan, 2003). Furthermore, the anatomy of the first web space is complex, which complicates the distinction between healthy and mildly diseased tissue. Our results indicate that this newly introduced measurement is accurate to determine the disease severity in patients without contractures. This adds value to clinical and scientific practice, since this

measurement can be used to study disease progression in patients with mild DD, and to study (early) recurrence after treatment.

This is the first study that investigates both intra- and inter-observer agreement in patients with DD. A strength of this study is the large number of 194 primary affected fingers. To compare, the only other study on reliability of goniometry measurements in patients with DD included 13 rays and found ICCs that ranged from 83.2-97.3% (Engstrand et al., 2012). In addition, we performed a sample size determination beforehand, and were able to include a sufficient number of participants. This enlarges the reliability of our results.

A limitation of this study is that the measurements were performed with non-validated instruments (tumorimeter, goniometer). However, it is unlikely that this led to bias, because the observers used exactly the same instruments interchangeably. Thereby, the use of these instruments enlarges the external validity, as it mimics the daily clinical practice. A second limitation is that the period between the first and the second visit varied between the participants. This could have negatively influenced the intra-observer agreement, since it is possible that the disease progressed between the observations. However, based on the literature concerning DD progression (Gudmundsson et al., 2001; Reilly et al., 2005), it is questionable whether considerable disease progression could occur in this time frame of 2-4 weeks. If some change has occurred, the ICCs are underestimated.

In conclusion, diagnosing DD and determining its severity using Tubiana classification, TPED, and the area of nodules and cords provides reliable findings with respect to both the intra- and inter-observer agreement. The agreement is high in general, but measurements are more difficult for the thumb and middle finger. The newly introduced

measurement of surface area of nodules and cords is a reliable method to study disease severity in patients with mild DD without contractures.

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CAPTIONS TO ILLUSTRATIONS

Photo 1. The finger goniometer.

Photo 2. The tumorimeter.

Figure 1. Schematic representation of the study procedure.

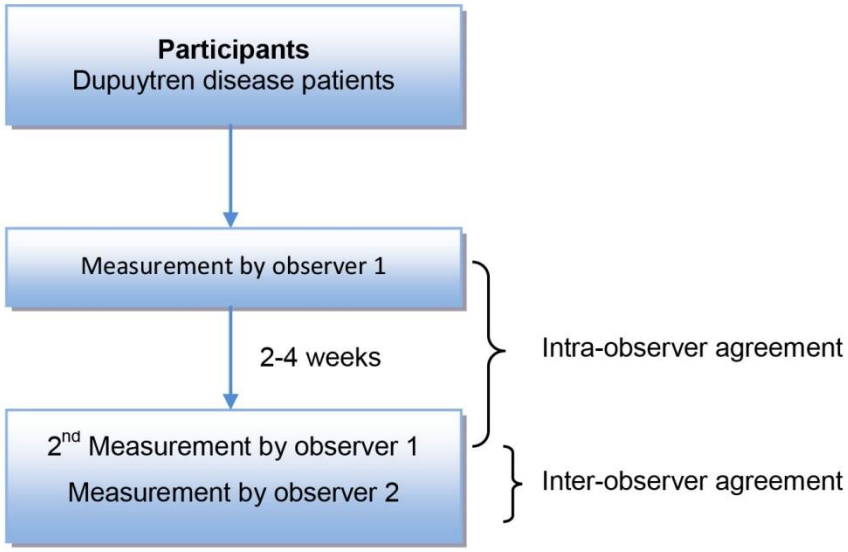

Figure 2. A) Occurrence of DD in different fingers, presented for each hand. B) Proportions of disease stages with respect to the total amount of affected fingers, presented for each hand.